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Sonar Transducer Reliability Improvement Program FY 79

First Quarter Progress

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Progress accomplished during the first quarter of FY79 in the Sonar Transducer Reliability Improvement Program (STRIP) is reported. Each of the nine program tasks is discussed in some detail. The most significant aspects are improvements in the gas-filling procedures for the TR155 transducers, results of accelerated aging of the TR215 transducers, the determination of only very low levels of noise radiated from the TR215 transducers, and the evaluation of several design changes on the AT200 and TR297 transducers.

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Sonar Transducer Reliability Improvement Program

NRL Problem 82 S02-43

FY 79 First Quarter Report

1. INTRODUCTION

1.1 PROGRAM OVERVIEW

The general objective of this program is to perform relevant engineering development which addresses the operational requirements for fleet transducers for active sonar, passive sonar, surveillance, countermeasures and deception devices, navigation, and acoustic communications. The approach is to develop, test, and evaluate improved transducer designs, materials, components, and piece parts that will meet specified requirements in the operational environment during the entire useful life of the transducer. Standards will be prepared to ensure that results obtained during preliminary testing will be obtained consistently in production. This program should result in improved performance and reliability and reduced costs through better utilization and a more comprehensive characterization of materials and design data. The program goals are as follows:

a. Improvement in transducer receiving sensitivity

Goal - less than ± 1 dB variation from the specified value over operational frequency band

Threshold - less than ± 2 dB variation from the specified value over operational frequency band

b. Improvement in transducer reliability

Goal - less than 1% of population failures each year

Threshold - less than 3% of population failures each year

c. Reduction in transducer replacement costs

Goal - less than 9% of population replaced each year with no automatic replacements at overhaul

Threshold - less than 18% of population replaced each year

d. Reduction in transducer radiated self-noise

Goal - less than sea state zero

Threshold - less than 10 dB above sea state zero

The Sonar Transducer Reliability Improvement Program (STRIP) is a part of Program Element 64503N. Major task areas with specific objectives to achieve the program goals have been described in the Program Plan and include:

Task Area A. Encapsulation Methods
Task Area B. High Voltage Engineering
Task Area C. Cables and Connectors
Task Area D. Transducer Material Standards
Task Area E. Environmental Test Methods
Task Area F. Noise and Vibration
Task Area G. Transducer Tests and Evaluation

The FY 79 program plan for STRIP has been funded at the $495 K level. The specific tasks and their Principal Investigators for FY 79 are listed below.

	Task	Principal	Investigator
A-1	Fluids and Specifications	NRL	C. M. Thompson
B-1	Corona Abatement	NRL	L. P. Browder
C-1	Cables and Connectors	NRL	R. W. Timme (Contract)
D-1	Materials Evaluation	NUSC	C. L. LeBlanc
E-1	Standard Test Procedures	NOSC	G. L. Kinnison (J. Wong)
F-1	Noise and Vibration	NOSC	G. L. Kinnison (C. Bohman)
G-1	Sleeve Spring Pressure Release	TRI	J. S. Thornton (L. Smith)
G-2	Test and Evaluation	NRL	A. M. Young
G-3	Engineering Documentation	NWSC	D. J. Steele (D. Moore)

1.2 SUMMARY OF PROGRESS

During the First Quarter of FY 79, efforts in the various tasks of STRIP have resulted in progress toward the program goals as summarized below:

a. The SF_6 gas-filling procedure for the TR-155 transducers (AN/BQS-6/11/12/13 and AN/BQQ-5) that was instituted at the Portsmouth TRF during August 1978 has provided zero defects and thus saved the Navy approximately $19,000 during 4 months of operation. See Section 3.3.2.

b. The accelerated aging of the TR-215 ( ) transducers (AN/BQS-8/10/14/20) has discovered another failure mode which is a decrease of impedance with time under high power drive conditions. See Section 6.3.2.

c. Measurements of the self-noise from the old and new TR-215 transducers (AN/BQS-8/10/14/20) indicate the radiated noise to be within acceptable limits. See Section 7.3.1.

d. A workshop for the TR-215 ( ) transducer (AN/BQS-8/10/14/20) was conducted to provide input from the reliability and life testing studies to the final design baseline. See Section 6.3.3.

e. Evaluation of polyalpha-olefin as a transducer fluid for possible use in the DT-605 hydrophone (AN/BQS-8/10/14/20) has been completed. See Section 2.3.1.

f. Recommendations for procurement specifications of acceptable voltage and corona levels for AN/BQS-4 sonar equipment have been made. See Section 3.3.3.

g. Evaluation of the AT-200 and TR-297 transducers (AN/UQN-1/4) has shown castor oil can be used instead of silicone oil as a fill-fluid, a Cu-Ni window is acceptable, and pressure relief compensation is unnecessary. See Section 9.3.1.

1.3 PLANS

The annual review for the STRIP will be held 21 February 1979, starting at 0830, in the Tracor Conference Room, Rockville, MD. The objectives of this meeting are:

a. to inform the NSEA managers, the laboratory sonar engineers, and the TRF engineers of R&D being directed toward their problems,

b. to inform the present and potential STRIP principal investigators of the transducer problems facing the fleet, and

c. to initiate planning for the FY 80 STRIP.

NSEA has issued time guidelines for preparing work-planning summaries for FY 80. The date of 1 May 1979 has been suggested as the deadline for firm plans for FY 80. Therefore, an invitation for proposals for work to be included in STRIP FY 80 will be extended at the annual review on 21 February. The deadline for proposals will be 31 March 1979. It is planned that the FY 80 STRIP plan will be ready by 1 May 1979.

1.4 REPORT ORGANIZATION

The remaining sections of this quarterly report will discuss the objectives, progress, and plans for the specific tasks included in the STRIP.

2. TASK A-1. TRANSDUCER FLUIDS AND SPECIFICATIONS

2.1 BACKGROUND

A material to be used for filling a sonar transducer must meet a wide variety of specifications. The requirements imposed by the electrical nature of the device include high resistivity, high dielectric constant, as well as resistance to corona and arc discharges. The water environment of the transducer necessitates low water solubility and other attractive solution properties. In addition, the fluid must maintain its electrical and other properties in the presence of any water which permeates the covering. The acoustic requirements are a close acoustic impedance match with sea water and resistance to cavitation at high drive levels. Other obvious properties include compatibility with the other components, stability to degradation, as well as suitable surface tension and viscosity.

With such a wide variety of requirements, it is not surprising that compromises have to be made. The most commonly used fluid for many years has been castor oil. This use is in spite of its high viscosity. Each of the fluids proposed, so far, as a replacement has serious drawbacks. Silicone oils tend to creep onto and wet all of the surfaces of the transducer. This greatly complicates bonding the components together. Polyalkylene glycol (PAG) has the disadvantages of a high water solubility and low electrical resistivity. The various hydrocarbon liquids have too low an acoustic impedance and are frequently incompatible with the various plastics and rubbers in the transducer. Further research is necessary to find and qualify fill fluids which represent the best match to all the requirements imposed upon it.

2.2 OBJECTIVES

The objectives of this task are:

a. To find plausible new transducer fill-fluids which combine all the best properties. Candidates include: hydrophobic polyethers, sterically protected esters, chlorine - or fluorine - containing hydrocarbons, methyl alkyl silicones, and possibly aromatic hydrocarbons.

b. To apply the criteria developed during the PAG and castor oil testing to the most promising candidate fluids.

2.3 PROGRESS

2.3.1 A series of tests were performed on polyalphaolefin (PAO) to determine its suitability as a transducer fill fluid. Hazeltine has proposed to use PAO as a fluid in the DT305 transducer instead of polyalkylene glycol which has recently become suspect.

Compatibility tests were performed for PAO and a variety of acoustic rubbers for 1600 hours. If an activation energy of 12 kcal/mole is assumed, a 90°C exposure for this period is equivalent to 6.5 years at 25°C. The results of this test are given below:

Material	Compatibility
BFG 35007 Natural	Disintegrated
Butyl H862A	Extensive swelling, no disintegration
EPDM Nordel 1070	Disintegrated
Butyl 70821	Disintegrated
Chlorobutyl B252	Disintegrated
Neoprene W	Lost 14% of weight
Nitrile	Lost 5% of weight
Castable Rho-c	Gained 28% of weight
PRC 1538 Polyurethane	Lost 5% of weight, became brittle
Viton A Fluoro elastomer	Lost 2% of weight
V121 Silicone	Lost 1% of weight
Lexan Polycarbonate	Lost 0.2% of weight

Attempts to study the water-PAO phase diagram were largely unsuccessful. This is a result of the very low water solubility in PAO and the attendant difficulties in maintaining a given concentration throughout a test. Despite the experimental scatter, the data leads to the following conclusions:

a. PAO has the lowest water solubility of any currently used transducer fluid. This value is (very approximately) 0.02%. Water precipitation from saturated PAO resulting from a change in temperature will present little problem.

b. The vapor pressure of PAO-water solutions as nearly as can be determined follows an ideal Raoult's Law line. The significance of this is that water will permeate relatively rapidly into a transducer filled with PAO until the solubility limit is reached. But, as previously mentioned, this limit is very low and so water should cause no difficulties in transducer operation.

The electrical resistivity of PAO is too high to measure with normal laboratory instrumentation even after aging. There is no reason at present to dispute the value of 10^{+17} Ω-cm claimed by the manufacturer. This is many orders of magnitude greater than is required for sonar transducer operation.

A summary of these results is:

a. Some difficulty will exist in finding rubbers which will not be degraded on exposure to PAO. Of the rubbers tested which are suitable for membranes, only Viton A could be rated as being excellent. The nitrile-butadiene tested could be rated as good. Of these, Viton A has a high acoustic impedance and nitrile-butadiene rubber suffers from low oxidative resistance. The silicone V121, and perhaps a polyurethane, should prove suitable as potting compounds in contact with PAO.

b. The acoustic impedance of PAO is about 17% lower than that of sea water. This mismatch will cause an increase in internal reflections and may result in a loss of directivity.

c. The very low equilibrium water content is a definite advantage. Very little water will permeate into a transducer filled with this fluid. The water which does permeate is unlikely to cause degradation of performance.

d. The very high electrical resistivity means that little problem will be experienced with loss of current or sensitivity.

e. This PAO is somewhat more viscous than is desirable for a transducer fill fluid. This material (Uniroyal PAO-20E) has a viscosity of 6.5 stokes at 21°C compared to 11 stokes for castor oil at this temperature. The viscosity of PAO changes much more slowly with temperature than does castor oil. At a temperature greater than 40°C, castor oil is less viscous than PAO. Thus, heating the fluid in order to aid in filling the transducer will be less effective for PAO than it is for castor oil.

In conclusion, PAO may be suitable for many sonar transducer application where the compatibility, acoustic impedance, and viscosity problems may be avoided.

2.3.2 Polytetramethylene glycol (PTMG) is a commercially available polyether. A molecular modification of PTMG should provide a compound with the advantages of PAG, but without some of the critical disadvantages. A modified PTMG has a lower proportion of ether oxygens than PAG and these are separated by four, rather than two carbons. Water solubility should be much lower than in PAG. The increased separation between oxygens avoids the problem of chelation of metal ions discovered in PAG. A limited study was begun into the feasibility of modifying commercial PTMG. The commercial material has too high a melting point (15°C), too high water solubility and too high viscosity, as a result of the intermolecular attraction between its hydroxyl end groups. The goal of the modification is to replace these end groups with some functional group which will not cause these problems.

The first attempt at modification involved "end-capping" the molecule utilizing the Williamson ether synthesis. This approach failed because of the low reactivity of PTMG toward elemental sodium. The second attempt was to dehydrate the end segment of the chain followed by hydrogenation. This approach failed because the PTMG de-polymerized under the harsh conditions of the dehydration. The third attempt involved reaction of PTMG with thionyl chloride to form the dichloride, followed by hydro-dechlorination by $NaBH_4$ in dimethyl sulfoxide (DMSO) solvent. This approach to date has produced a small amount of fluid with apparently useful properties. It has a density of 1020 Kg/m^3 and an approximately correct viscosity. Unfortunately, the current material has a very unpleasant odor, probably due to contamination with decomposition products of DMSO. Because of the difficulty in purifying this material, one additional attempt will be made utilizing the dichloro compound from above. A reverse Williamson either synthesis will be used to place methoxy groups on this compound. If the synthesis is successful, appropriate tests will be run on the product.

2.4 PLANS

2.4.1 Write and publish reports on castor oil-water phase diagram and vapor pressure behavior.

2.4.2 Continue search and qualification testing for transducer fill fluids.

2.4.3 Synthesize, and test the dimethyl-capped PTMG.

2.4.4 Prepare a report on the properties, interactions, and tradeoffs for the best fill fluid.

3. TASK B-1 CORONA ABATEMENT

3.1 BACKGROUND

A significant percentage of transducer failures is due to voltage breakdown of insulating materials developing from corona erosion mechanisms. It is not practical to test the end item (transducer) to quantify the effects of corona erosion on transducer reliability and lifetime. Corona must be studied as a failure mechanism at the component or piece part level to quantify the protection requirements and establish reliability factors. Transducer reliability may then be achieved by control of design parameters and construction processes.

3.2 OBJECTIVES

The objectives of this task are:

a. To provide guidance in selecting materials useful in corona abatement for sonar transducers.

b. To reduce corona and flashover damage by quantifying voltage breakdown levels with various design parameters that may be specified and controlled.

c. To study the insulating properties and corona resistance of the piezoelectric ceramic material that is an essential part of sonar transducers.

d. To identify and test various thin films and coatings with high dielectric strength to establish their usefulness at reducing corona.

e. To determine the quality control factors to be considered for corona abatement materials and methods selected for use in transducers.

f. To provide guidance for establishing general specifications for corona abatement and high voltage design and construction.

3.3 PROGRESS

3.3.1 Continuing study of the technical literature concerning breakdown products of the electronegative gases, particularly the perfluorocarbons and sulfur hexafluoride, in the presence of an electric arc [1] has yielded results applicable to sonar transducers. The major end product of arcing in the perfluorocarbon gases is CF_4 (perfluoromethane) and carbon. The electrical strength of CF_4 is greater than air, but less than the strength

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[1] J. P. Manion, J. A. Philosophos, and M. B. Robinson, "Arc Stability of Electronegative Gases," IEEE Transactions on Electrical Insulation, Vol. EI-2, No. 1, April 1967.

of the recommended perfluorocarbon gases (C_2F_6, C_3F_8, and C_4F_{10}). CF_4 is chemically stable in the presence of electrical discharges and presents no chemical corrosion problems. The net result of the generation of CF_4 from the larger perfluorocarbon molecules is an increase of pressure inside the transducer that will partially stabilize the breakdown strength of the gas mixture.

It is reported [1] that the major decomposition product of sulfur hexafluoride (SF_6) in electric arcs is SF_4, a gaseous compound both toxic and corrosive. The STRIP investigation has also tentatively identified SO_2, H_2S and fluorine gas by-products. All of these breakdown products have the potential to produce corrosion products and trigger a failure mechanism in a sonar transducer if present in the gaseous fill fluid in sufficient quantity.

This task has shown that perfluoroethane (C_2F_6) or "Freon-116"® is equal or superior to sulfur hexafluoride for use with sonar transducers. The major advantages of C_2F_6 as opposed to SF_6 in transducer designs such as the TR155 are the 20% higher flashover voltage to be expected and better retention of dielectric strength with the stress of operation. The cost of C_2F_6 is approximately 50% above that of SF_6 ($0.30 vs. 0.20 per transducer), but is still very insignificant compared to the cost of a TR 155 transducer.

It is recommended that a pilot test program be implemented with fleet transducers using C_2F_6 for the insulating gas to prove its reliability.

3.3.2 Communication was maintained with the Transducer Repair Facility, Portsmouth, New Hampshire, to monitor the problems associated with the gas filling procedure for the TR 155 transducers. Information was requested concerning the high voltage test failures before-and-after 8 August 1978, the date of the gas filling procedure change. The following results were reported as of 17 December 1978:

1 Jan-8 Aug 1978			8 Aug-17 Dec 1978			
Processed	Failed	%	Processed	Failed	%	Approximate Savings
848	47	5.5	649	0	0	$19,000

The documented reduction in failure rate has resulted in a tangible savings to the Navy of approximately $19,000 in the four month period since the procedure change at the one TRF alone. Very substantial, intangible benefits have probably also occurred in that borderline transducers, that previously would have been passed to the fleet, have been reduced in number.

It is requested that NAVSEA 660T require all TRF's to maintain accurate records of high voltage test failures until 30 June 1979. This will help assure that the gas filling procedure is adequate.

3.3.3 A request was received from NAVSEA, Code 660C for assistance concerning corona specifications on the electronic ciruitry of the AN/BQS-4 ( ) active sonar. The applicable specifications are MIL-E-16400G (Navy) and MIL-STD-454F. The problem involved is that the corona specification may be interpreted to apply to low voltage equipment as well as for higher voltages.

The response to the request indicated that the corona phenomena does not occur in ambient air at voltages below the Paschen minimum, generally measured as 340 volts dc or 240 volts ac. This applies to an electrode spacing of about 0.00075 cm (0.3 mil). For equipment operating at voltages lower than this, a corona specification is unnecessary.

In a memorandum to NAVSEA 660C, dated 1 Nov 1978, it was recommended that:

(a) There should be no corona specification on components or equipment with operating voltages less than 340 V dc or 240 V ac.

(b) Corona specifications be optional on components or equipment with operating voltages between the Paschen minimum and 600 V dc or ac.

(c) Corona specifications are useful or mandatory on components and equipment with operating voltages or transient peak voltages exceeding 600 volts.

3.3.4 The Biddle corona measuring system was received and put into operation. The first applications of the instrument have been to establish the parameters for evaluation of transducer corona at the piece part level.

Figure 3.1 presents data concerning corona inception voltage (CIV) of ambient air obtained using the corona detector. The spherical point-to-plane electrode configuration is a useful beginning because comparison results are available in the technical literature and it illustrates important considerations involving corona phenomena. After the insulating gas type has been chosen for transducer use, the next most significant factor in corona abatement is increasing the radius of curvature (r) of the metal electrodes. Figure 3.1 shows the variation of CIV with various point radii. The range of r used was 0.0065 - 0.317 cm corresponding to the rounded end of platinum wire of gage size 36, 32, 26, 20, and 14, and the largest size was 0.635 cm (0.25 in.) brass rod. Curve A is an approximate indication of the uniform field breakdown voltage of ambient air. The voltage indications are peak values and should be multiplied by 0.707 for equivalent rms levels. The results indicate that CIV increases approximately as a function of $\sqrt{r}$. Thus to double the CIV requires increasing the radius by a factor of four. Also, the CIV is not directly proportional to electrode separation distance (d), but more nearly to $d^{.15}$ while changing from 0.1 to 4 cm.

Curve B of Figure 3.1 shows the CIV function of a 2 cm length of #20 gage platinum wire with its axis parallel to the plane electrode. At a distance of approximately 50 radii and greater, the CIV is the same as the equivalent r point-to-plane level. With smaller values of d, the CIV increases until it rolls off to coincide with the uniform field characteristic. Thus, over a wide range of d, the CIV level of a length of wire is essentially constant. The way to increase the CIV level of wiring is to use a larger gage size. It is here that the $\sqrt{r}$ function of

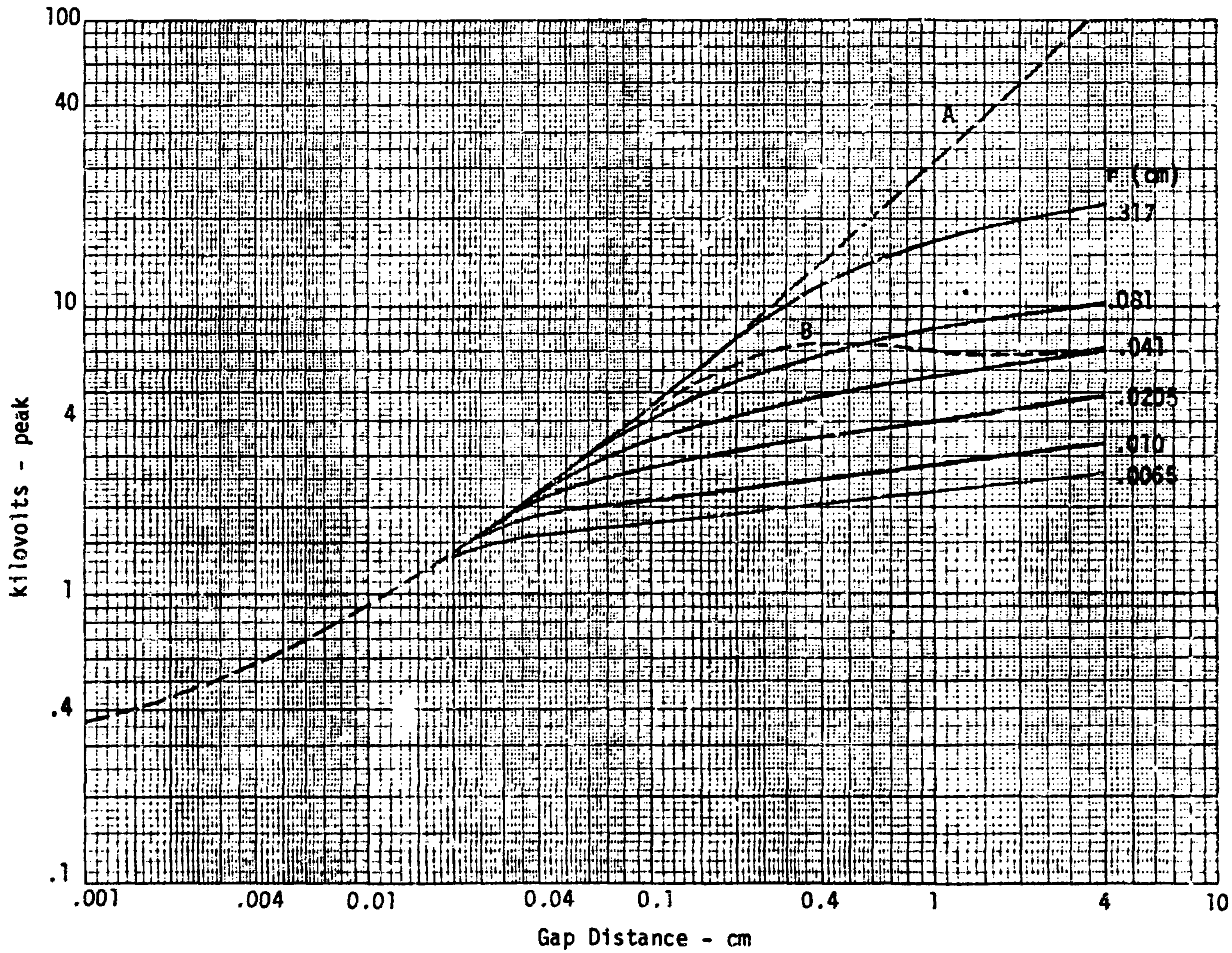

Figure 3.1 corona inception voltage in air

CIV is most noticeable. For instance, it is estimated from this data that to use the full 40 kV (56 kV peak) capability of the Biddle testor will require a high terminal conductor (copper tube) having a diameter of at least 2 cm. For corona-free operation, the maximum voltage that can be applied to the various wire gage sizes in ambient air is as follows:

(1) #14 - 7.1 kV (rms)
(2) #20 - 4.8 kV
(3) #26 - 2.8 kV
(4) #32 - 1.8 kV
(5) #36 - 1.3 kV

It is likely that the CIV function for other electrode edge configurations, including those electroded on PZT ceramic elements, will be similar to the parallel wire-to-plane results.

The initial tests utilizing thin coating materials of less than 1 mm thickness for corona abatement purposes in transducers have yielded marginal or negative results. Even a sheet of solid glass in the gap does not inhibit the formation of corona except with very fine points and electrode spacing less than 0.5 mm. In some tests, the CIV was actually lowered by introducing the solid insulating material. Further exploratory tests will be conducted.

3.4 PLANS

3.4.1 Construct and evaluate a gas test chamber to allow measurement of corona inception voltage of gases and gas mixtures at the transducer piece part level.

3.4.2 Evaluate PZT ceramic corona inception voltage levels and ceramic lifetime functions.

3.4.3 Continue evaluation of corona phenomena with various dielectric coating materials.

4. TASK C-1. CABLES AND CONNECTORS

4.1 BACKGROUND

The use of cables and connectors is an area of concern for long term sonar reliability becuase of a history of failures. Deficiencies can be generally categorized in the four areas of: design of cables and terminations; specification and testing; handling; and repair and maintenance. Specific problems have been identified in a recent failure modes and effects analysis of cables and connectors prepared for NAVSEA by General Dynamics/Electric Boat. They conclude, that of all the problem areas, the loss of bond of the molded boot to the connector shell or to the cable sheath is the most probable cause of failure. Cable jacket puncture in handling, at installation or in service is considered to be the second most probable cause of failure. These are the two problem areas to be addressed here.

4.2 OBJECTIVES

The general objective of the task is to provide improved reliability in the cables, connectors, and related hardware for the outboard elements of sonar transducer systems. It is occasionally necessary to also consider portions of the system interior to the ship's hull because the same cables are often used for significant distances through compartments inside the ship before terminating at their ultimate electronic package destination.

Specific objectives for the FY-79 task are as follows:

a. Investigate the use of cable/connector boot clamps to determine reliability and failure modes,

b. Investigate the strength of unshielded cable and shielded cable to determine reliability and failure modes.

4.3 PROGRESS

4.3.1 A workshop on the reliability of transducer cables and connectors was hosted by NOSC on 19 October 1978. The FMEA referred to above was presented by GD/EB and considerable discussion followed about what is needed to increase the reliability and life of cables and connectors. Figure 4.1 summarizes that discussion. There could be another branch under the "Improve present connector approach" which could be called "Double O-ring", but it has been omitted because most engineers feel the desirability of a double O-ring in a connector has already been proven through years of experience. The possibilities of significant advances in several of the investigations depend upon better control over rubber which cannot be provided at present. The paths which should yield the most immediate and useful results are indicated by arrows on Fig. 4.1. These have become the objectives of this task for this fiscal year.

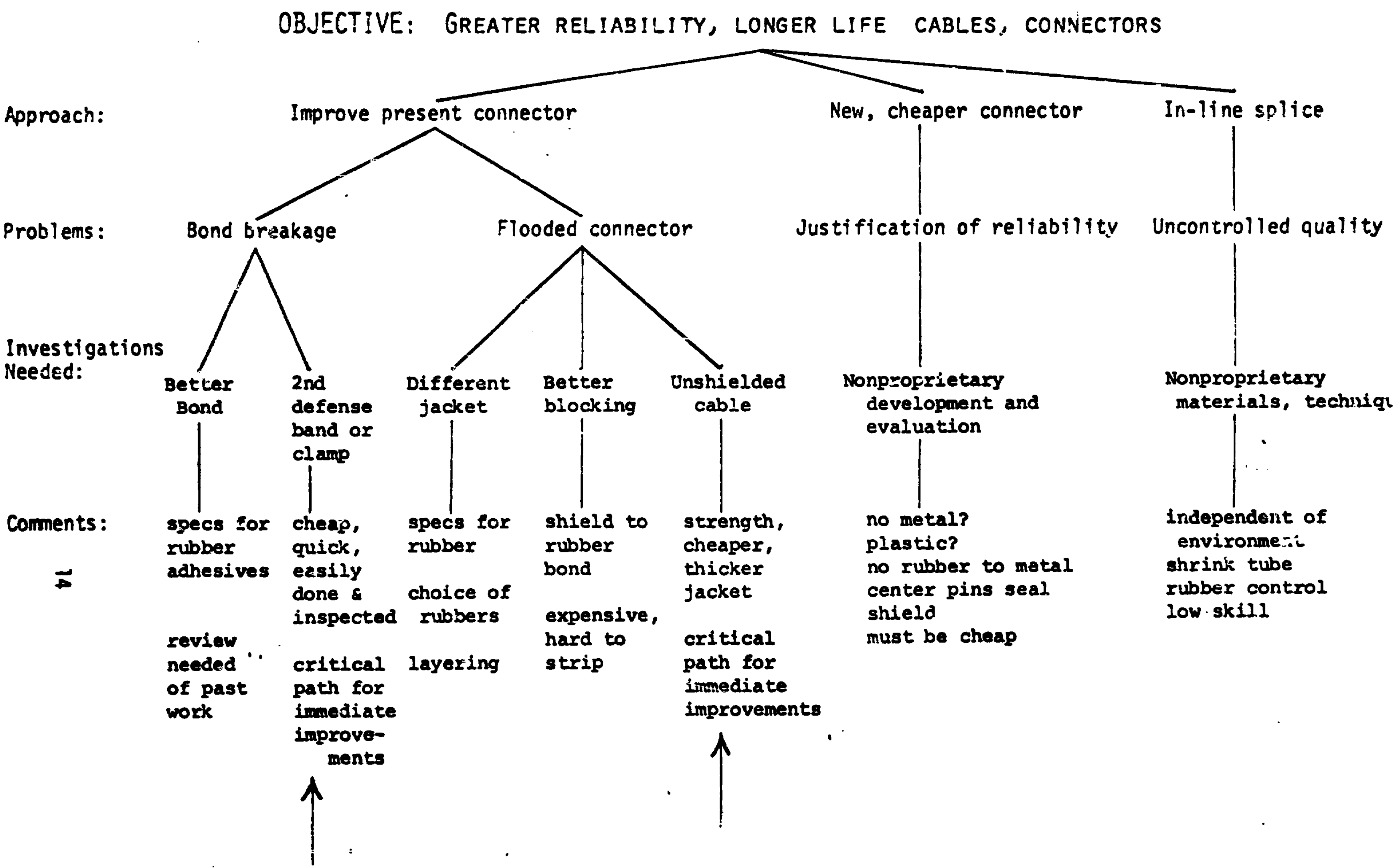

Figure 4.1 The approach to more reliable, longer lived transducer cables and connectors.

4.3.2 The electrical cable is joined to the connector plug by a molded boot usually of neoprene or polyurethane. Considerable discussion has ensued over the past decade on the merits of neoprene or polyurethane in this application. In each case, there have been reports of failed cable/plug assemblies following short periods of ship operations, but it is also known that assemblies have performed satisfactorily from submarine fabrication to overhaul. It is generally agreed, however, that rubber-to-metal bond deterioration occurs in sea water over a period years regardless of the bonding system or rubber formulation selected. It has been suggested the flooding of the cable/connector due to the bond deterioration could be avoided with the use of various simple clamping or banding systems which would provide a positive seal independent of the bonding between the molded boot and the connector shell and cable. This might be a simple solution, but a quantification of advantages and disadvantages are required before widespread fleet application can be made.

Cable jacket puncture, with the subsequent cable flooding and loss of insulation properties between the shield and ground, is a known failure mode which could possibly be avoided by using unshielded cable that is more easily water-blocked. Unshielded cable has been used on several sonar systems with the authorization of NAVSEA. This decision was based on no electromagnetic interference problems, however, and did not consider cable strength. There are insufficient data on both the strength of cables and the strength required of cables. One argument is that unshielded cable does not have the strength needed for handling and installation, but there is reasonable doubt whether or not shielded cable might actually have less usable strength than an unshielded version because of the damaging effects of the shield wires. In general, neither the behavior of existing cable designs nor the requirements for them are quantitatively known in the areas of overall strength and mechanical failure modes. It is essential to conduct a rather basic analysis and test program to set standards and provide comparative data on existing designs. From this information it should be possible to determine what improvements actually need to be made and to develop new designs with confidence once requirements are selected.

This work will be performed under contract. An RFP is currently being advertized.

4.4 PLANS

Proposals from interested parties will be reviewed and a contract will be let with work to start during the second quarter.

5. TASK D-1. MATERIALS EVALUATION

5.1 BACKGROUND

Pressure release materials are used to mechanically and/or acoustically isolate some components of sonar transducers to improve overall acoustic performance. Normally the pressure release materials must operate effectively under bias stress anywhere from 50 psi to 3 kpsi over a discrete temperature range, e.g., 5°C to 40°C. To predict performance it is essential to know the properties of the materials under the imposed constraints. Previous measurement methods for determining the properties of some pressure release materials, such as Sonite (an asbestos - glass fiber composite), onion-skin paper, syntactic foams, Hytrel (a thermoplastic polyester elastomer), etc., have given relative results with a hydraulic press or bulk effects with an impedance tube. There is a strong need to correlate existing measurement data and to establish a standard measurement system to be used by the Navy for incorporation into specifications and/or acceptance tests on pressure release materials.

An additional problem is that pressure release materials absorb the transducer fill fluids. This process increases the acoustic impedance of the pressure release material and thus reduces the effectiveness of its acoustic insulation. Degradations of from 3 dB in 3 years to 6 dB in 10 years have been reported in transducers in the field, and attributed to changes in the pressure-release material.

There are thus two phases to this task: the material characterization phase which is just beginning; and the fluid absorption phase which is nearing completion.

5.2 OBJECTIVES

The objectives of this task are:

a. To initiate and evaluate a standard dynamic measurement system for determining the properties of pressure release materials over the ranges of stress from 50 psi to 3 kpsi and at temperature from 5 to 40°C.

b. To measure and evaluate candidate pressure release materials, such as Sonite, onion-skin paper, corprene, etc.

c. To quantify the changes in acoustic properties of cork-rubber composites as they absorb transducer fill fluids.

d. To develop a math model that will predict changes in the acoustic properties of cork-rubber composites with time (and in turn predict changes in transducer directivity and sensitivity).

e. To identify the specific problems with DC 100 which may eventually lead to its replacement with a more suitable material.

5.3 PROGRESS

5.3.1 This is the first reporting period for this specific phase. To demonstrate the feasibility of establishing a standard dynamic measurement system a double mass-loaded longitudinal resonator (tonpiltz) was assembled from parts remaining from a previous program. One end mass of the assembled resonator was mechanically loaded with a composite structure consisting of a puck of pressure release material plus an additional loading mass. The pressure release puck and loading mass were in tandem and were bolted into the end mass with a separate stress rod to control the stress level on the pressure release material. Initial measurements indicated that the low frequency resonance of the simple loading mass and the compliance of the pressure release material could be altered substantially by simply increasing the stress level on the pressure release puck. Thus, the properties of the pressure release material can be obtained by monitoring the low frequency resonances and their associated mechanical quality factors and by incorporating the measured data into prediction math models. In addition, computer analysis of the complete assembly from the electrical driving port should also yield the properties of the pressure release material. Both methods of determining the pressure release properties will be used to cross reference the data.

5.3.2 Although the most commonly used pressure release cork rubber composite is the Armstrong DC-100, cork-neoprene mixture (corprene), other composites are also produced by Armstrong which may, in fact, have superior properties. The following composites have been purchased from Armstrong and are being tested and compared:

a.	chloroprene - cork	DC-100
b.	chloroprene - cork	DC-116
c.	nitrile-butadiene-cork	NC-710
d.	nitrile-butadiene-cork	NC-775
e.	silicone-cork	LC-800

These materials are immersed in castor oil, silicone oil, and polyalkylene glycol, (PAG), and the permeation of the fluid is monitored spectrophotometrically, microscopically, and gravimetrically. Some of the tests are being conducted at elevated temperatures (75°C and 100°C) to accelerate the tests and to determine the temperature dependence.

The gravimetric analysis of oil permeation has been conducted for eight months (6000 hours) to date. Most of the cork-rubber composites are being tested with most of the fill fluids at 25°C, 75°C and 100°C.

The gravimetric analysis for the 100°C samples was terminated at 7 months (5000 hours). At this time, most of the 100°C samples had deteriorated to such a point that further testing would prove useless. All samples were crumbling, distorted, blistered, swollen, or shrunken.

Table 5.1 shows the change in volume over the 5000 hour test period. The initial volume of all samples was 47.6 cubic centimeters (15 cm x 10 cm x .32 cm).

Table 5.1 Sample Volume and percent change after 7 months at 100°C

oil	castor oil		silicone oil		PAG	
composite	volume	% change	volume	% change	volume	% change
DC-100	51.0 cm^3	+ 7%	45.5 cm^3	- 4%	55.1 cm^3	+16%
DC-116	50.1 cm^3	+ 5%	c		c	
NC-710[b]	52.3 cm^3	+10%	44.1 cm^3	- 7%	50.2 cm^3	+ 5%
NC-775	a	a	c		c	
LC-800	52.6 cm^3	+11%	62.6 cm^3	+32%	60.4 cm^3	+27%

a. Terminated at 1 month due to severe blistering.
b. Terminated at 6 months due to blistering
c. Combination not tested.

Table 5.2 shows the Shore hardness of the samples as given by Armstrong Cork Co., as determined in the lab before testing, and at completion for the 100°C test samples.

Table 5.2 Shore hardness before testing and after 7 months at 100°C

oil	Armstrong	NRL		Castor Oil		Silicone Oil		PAG	
composite	range	range	Average	range	Average	range	Average	range	Average
DC-100	55-70	65-71	68	16-28	22	86-99	95	45-60	52
DC-116	60-75	69-72	70	17-25	21	N/A	N/A	N/A	N/A
NC-710	55-70	72-75	73	28-53	43	91-99	96	57-73	66
NC-775	70-80	76-79	78	N/A	N/A	N/A	N/A	N/A	N/A
LC-800	63-77	71-74	72	51-62	58	58-63	61	35-43	40

It is apparent from the above tables that drastic changes have taken place in volume and/or hardness of every combination tested. Comparisons with the 25 C and 75 C samples, at longer times, will determine if these changes are due to accelerated exposure to oil or simply to the elevated temperature.

Difficulties have arisen with the use of infrared spectrophotometry to monitor the oil permeation. The feasibility of this method was based on spectra obtained from the different cork-rubber composites and the transducer fill fluids, and the outer surface at the composites soaked for short periods in the fill fluids. The tests were conducted using multiple internal reflectance techniques. Early tests showed there should be a very intense absorption peak at a wave number of 1450 cm-1 when castor oil is present that is not found in the spectra at DC-100. When actual tests were started, the 1450 cm-1 absorption peak was not well defined and no other peak could be found of sufficient intensity for quantitative work. The problem seems to be that the preliminary tests were conducted on samples simply coated with castor oil. This produced a spectrum of castor oil with a slight influence from the cork rubber composites. When the actual testing was started and the samples were sectioned, the spectrum was that of DC-100 with only a slight influence of castor oil. The castor oil peaks were present but not of sufficient intensity for quantitative analysis. Further work will determine if the spectrophotometric tests can still be useful for fluids with different infrared spectra, such as silicone oil or PAG. Other testing methods are being investigated to replace the spectrophotometric techniques. These involve cutting thin sections out of the soaked composite, followed by either density determination or extraction and spectrophotometric analysis.

5.4 PLANS

5.4.1 The dynamic measurement scheme will be refined to include a detachable sample holder which can be prestressed separately and then mounted on one end of a longitudinal resonator which will be freely suspended. Two math models will be developed: one to treat the low frequency resonance of the detachable sample holder and the other to analyze the complete composite assembly, including the sample holder, from the electrical driving port. The math models will be used to predict the properties of the pressure release materials from measured data.

5.4.2 A known material will be inserted into the sample holder and the properties will be determined over the designated temperature and stress ranges to ensure that the measurement scheme and math modeling techniques are working appropriately. Finally, selected pressure release materials will be measured and categorized.

5.4.3 Gravimetric analysis will end February 4, 1979, for 75° samples, and 25° samples will continue indefinitely.

5.4.4 Impedance tube testing of the soaked samples will begin in January 1979.

5.4.5 With information accumulated from the above tests, a math model will be formulated and tested on a transducer element. Recommendations will be made about either a better pressure release material, a method to minimize changes in existing materials or a way to compensate for changes.

6. TASK E-1. STANDARDIZED TEST PROCEDURES

6.1 BACKGROUND

It is at present not possible to subject a transducer specimen to a series of environmental stresses over a short time period and prove, if it passes certain operating parameter tests, that the specimen is a reliable transducer with a certain minimum expected life in fleet use. Of course, if we could simply use a set of transducers for the desired fleet life, we could check the failure rates against acceptable replacement or repair rates. But the approach here is to accelerate the environmental stress actions, and thereby subject the transducer specimen to seven years of life cycle stresses in a few weeks or months.

6.2 OBJECTIVES

The objective of this task is to develop a set of standardized procedures to accelerate the aging of transducers based upon environmental stress requirements.

6.3 PROGRESS

6.3.1 In July 1978 the three Ametek-Straza prototype TR-215 ( ) projectors were returned to Ametek-Straza for modification to correct the defects discovered during the first five steps of the first year of accelerated life aging. The following modifications were completed in October 1978.

a. The resonator cavitites, spaces between the ceramic inside-diameter and the stress rod, were filled with Sylgard 184 (Dow Corning) to prevent air entrapment.

b. The damaged pressure release pads were replaced.

c. The acoustic windows on the wide beam up section of projector S/N4, which had leaks, was replaced.

d. The ice shields with the rubber windows should have metal to metal contact with the housing when secured with the screws, providing more positive sealing against water intrusion.

6.3.2 High power continuous drive at low operating frequency in 60 ft. of ocean water for 170 hours (7 days) was started in November 1978. The high power drive test was the last sequence in the Accelerated Life Test Plan on the TR-215 ( ) which completes an equivalent of a one year exposure to environmental stress.

Prior to the high power drive test the beam patterns, input imepdances and the transmitting voltage responses (TVR) of the three projectors were measured at low level (10 volts) to obtain a base line reference. All beam patterns, input impedances and TVRs were within specification. Also, the hardness and the expansions of the rubber windows were measured for future comparisons at the various stages of the accelerated life test.

The three projectors were mounted side-by-side on a support frame and lowered to a depth of approximately 60 ft. of ocean water. Any six of the nine beam sections can be driven simultaneously and the input currents to each of the six beams are monitored with a 6-channel Brush recorder. The lowest frequency in the operating band was used as the drive frequency at 125 volts rms, C. W. This frequency was selected because the projectors draw higher power at this frequency than at any other frequency in the band thus, providing a more severe high drive test.

At the beginning of the test, wide beam up section of S/N3 and wide beam down section of S/N4 units were found defective. After approximately 20 minutes to 75 minutes of high power drive the down beam section of S/N4 and up beam section of S/N3, respectively, started to draw currents exceeding 4 amps. The same result was repeated twice. It appears that the heating effect of the current starts to breakdown some components in the projectors, possibly in the input transformer circuitry, causing a decrease in the impedance. These two beam sections were not used in the remaining test. A total of 171 hours (167 hours were continuous drive) of high power drive were accumulated as summarized in Table 6.1.

Table 6.1. Summary of the high power continuous drive test on the Straza TR-215 ( ) at 60 ft. ocean water depth.

Input voltage is 125 V (rms) at end of 150 ft. cable.
Frequency is CW at low end of the operating freq. band.

Unit	Beam Section	Total Hrs.	Average input current, Amp (rms)
S/N2	PD (Wide Beam) Up	171	2.10
	IBD (Narrow Beam)	171	2.39
	PD (Wide Beam) Down	171	1.71
S/N3	PD (Wide Beam) Up	--	Defective*
	IBD (Narrow Beam)	171	2.91
	PD (Wide Beam) Down	1 1/2**	1.96
S/N4	PD (Wide Beam) Up	171	1.84
	IBD (Narrow Beam)	171	1.21
	PD (Wide Beam) Down	--	Defective***

* Initial input current equals 2.05 amps (rms), starts to draw current exceeding 4 amps after approx. 75 minutes of high drive.

** Did not finish required hours of high drive.

*** Initial input current equals 1.75 amps (rms), starts to draw current exceeding 4 amps after approx. 20 minutes of high drive.

Inspection of the currents drawn by the various beams of the three projectors (Table 6.1) shows variation with the base line reference impedance magnitudes measurements.

Approximately 15 days after the high drive test the beam patterns, input impedances and TVRs measurements on all three beam sections of S/N2 projector show no significant changes compared to the base line reference. Time did not permit to check projectors S/N3 and S/N4. The rubber window hardness and expansion were also measured. No significant changes in the rubber hardness were detected. However, the window of the wide beam up section in S/N4 projector had expanded approximately 55 mils compared to that before the high drive test. Causes of this expansion are not known at this time.

The second year of accelerated life aging was initiated on the TR-215 ( ), two TR-242's and one DT-605. This cycle of life testing is scheduled to end 21 Mar 79.

6.3.3 A special reliability review for the TR-215 ( ) transducer was hosted by NOSC on 17-19 October 1978. The meeting was organized to focus the reliability activities on the new TR-215 ( ) projector design before a final baseline was established. A failure modes and effects analysis was presented in detail by GD/EB and discussed at length. TRI described the transducer reliability model of the TR-215 ( ) and the implications on lifetime. Reliability tests and accelerated life tests were described by NOSC. The accelerated life tests and failure mode analysis have discovered weak points in the design, as has been pointed out in the STRIP FY 78 Fourth Quarter Report. These weak points have been corrected in the design and the implications are being documented. In attendance at this reliability review were representatives from NOSC, NSEA, NRL, NWSC, NUSC, TRI, GD/EB, and Ametek-Straza Div.

6.4 PLANS

6.4.1 Determine the cause of the defects in the beam sections of projectors S/N3 and S/N4.

6.4.2 Continue with the second year of accelerated life aging on the TR-215 ( ). Three additional transducers, two TR-242's and one DT-605 are also included in the accelerated life aging.

7. TASK F-1. NOISE AND VIBRATION

7.1 BACKGROUND

As the requirement for more sensitive and quieter sonar operation becomes more important, the problems of self - and radiated-noise also increase. The very real problem of transducer produced noise has already been highlighted. Transducer self-noise can block out that transducer's operation as well as radiate out into the medium. Radiated noise can also interfere with other acoustic systems of a ship or submarine. Because of those problems, all new or improved transducers should be scrutinized for noise sources. At present there are no fully accepted methods for correlating the radiated noise from an installed transducer with the results of a laboratory test for noise.

7.2 OBJECTIVES

The objectives of this task are to:

a. Analyze and evaluate noise and vibration criteria and sources in transducers and their mounting systems.

b. Develop analytical and test methods for evaluating transducer noise.

c. Prepare or update noise and vibration standards for sonar transducers.

7.3 PROGRESS

7.3.1 Honeywell test

On September 12-15, 1978, self-noise pressure tests were conducted on the center sections of the new (Straza) and old (Hazeltine) TR-215 transducers. During this test the TR-215 sections were placed in individual, side-by-side pressure tanks with two calibrated monitoring hydrophones-one positioned near the top of each tank and one near the bottom. The electrical conductors of the TR-215 sections were brought out of the pressure tanks along with the outputs of the monitoring hydrophones. The output voltages of the transducers and hydrophones were amplified and recorded at various times during the pressure testing. During one part of the test the TR-215 sections were removed and the self-noise of the pressure tanks was recorded while pressure cycling. The tapes of data recorded during the tests were then analyzed.

The criteria[1] being used to evaluate the detectability of the self-generated radiated self-noise of the TR-215 transducer is applied to the results of three different methods of analyzing the radiated self-noise:

[1]STRIP Second Quarter Report, Task F-1, April 1978

a. average energy spectral density,

b. peak channel energy spectral density, and

c. peak level energy spectral density.

In method (a), a large number of transients (typically 500 or more) are sampled and the average energy spectral density in $\frac{\text{Joules}}{\text{m}^2\text{-Hz}}$ is calculated.

In method (b), the peak energy spectral density is obtained from the same group of transients by calculating the energy in each frequency channel or bin and holding the peak value in each channel as measured from any of the transients. Method (c) is similar to method (b), but instead of accumulating the peak energy in each frequency bin as the result of many transients, the peak level energy spectral density is the E.S.D. of the single transient having the greatest total energy of all the transients sampled.

The group of transients chosen to be sampled are those which exceed a specified pressure threshold, such as 112 dB re 1 μPa, during a specified time period. The results of methods (a), (b), and (c) are compared to the maximum acceptable source spectrum level as calculated in the STRIP Second Quarter Report. Method (b) is a "worst case" measurement because it accumulates the maximum source level measured in each frequency channel. Method (c) measures the energy spectral density of the worst transient, or the transient having the most total energy.

From the data already analyzed, it is apparent that the voltage measured at the electrical outputs of the TR-215 sections is not sufficient to provide complete information on the radiated self-noise. Much of the noise that was observed by the monitoring hydrophones could not be observed during the same time interval from the TR-215 electrical outputs. It appears that the self-generated noise of the TR-215 is not well coupled to the individual hydrophone elements through the mechanical structure of the transducer. It is also informative to point out that the outputs of the individual hydrophone elements of the TR-215 are connected in parallel and unless each hydrophone element thus connected receives the same excitation at the same time, the overall voltage response level at the output of the transducer will be less than the original excitation because of the effective averaging of all elements.

In general, the E.S.D. of the radiated self-noise as measured at the input of the monitor hydrophones of both the old (Hazeltine) and new (Straza) TR-215 sections was within -5 dB to +10 dB of the maximum acceptable level as set forth in the Second Quarter Report, 1978. The range of measured levels is due to the different methods of analysis as explained above. The energy spectral level is also dependent on the analyzer input trigger level, which when set at a low level, includes lower energy transients in the average E.S.D.; which increases the total transient count, but decreases the average E.S.D. If - 10 dB is allowed for attenuation in referencing the source level to one meter range, then the worst case E.S.D. measurement is still within the proposed maximum acceptable source level.

7.3.2 Free field measurements test

Recognizing that self-noise measurements taken in relatively small pressure tanks have many unknowns associated with them, efforts have been underway to develop a test vehicle which would allow free field measurements to be taken at Pend Oreille, Idaho. This vehicle would allow the transducer being tested to be partially enclosed to reduce flow noise while raising and lowering the test vehicle in approximately 1,200 feet of water and at the same time making self-noise measurements. Monitor hydrophones would be mounted approximately one meter away from the transducer to measure the near field self-noise. Other hydrophones would be placed in fixed positions at a greater distance for far field measurements.

This vehicle has been built and has undergone initial testing for hydrodynamic stability and platform quietness. The initial tests have shown the vehicle to be hydrodynamically stable and with proper care and a few minor modifications, it should be quiet enough for low-level noise measurements.

7.3.3 Crane tests

NOSC, San Diego and NWSC, Crane, Indiana have been cooperating in the testing and calibration of the automated pressure tank facilities at Crane. Four hydrophones, each having a sensitivity of -180 dB re 1V/1μPa, have been sent to Crane for calibration and testing purposes. Crane has been pressure cycling one DT-308 and one DT-605 for side-by-side self-noise pressure tests. The old (Hazeltine) and new (Straza) TR-215 transducer center sections will also be tested at Crane.

7.4 PLANS

a. During the next quarter the recorded Honeywell test data analysis will be completed and a report written on the results. This report will also include the results of the radiated self-noise tests of the pressure release material, Sonite, which is being used in the TR-215 ( ).

b. A test plan will be written for the utilization and deployment at Pend Oreille of the test vehicle designed for free field measurements. This test plan will include the instrumentation details and test procedures.

c. Cooperation will continue between NOSC and NWSC in the calibration and testing of the Crane pressure tank facilities and a brief report on the facilities will be forthcoming.

d. The small pressure tank and instrumentation used for piece-part self-noise measurements will be reassembled and calibrated for measuring test samples of pressure release materials.

8. TASK G-1. SLEEVE SPRING PRESSURE RELEASE MECHANISM

8.1 BACKGROUND

Some transducers in use by the fleet have been found to emit extraneous electrical and acoustical noise as a function of changing hydrostatic pressure. The primary source of the noise is believed to originate in the pressure release mechanism of the transducers. Interim fixes have been implemented, but final solutions require the development of new pressure release mechanisms.

8.2 OBJECTIVES

The objectives of this task are to develop, fabricate, test, and evaluate an alternative pressure release mechanism. The new pressure release mechanism will be in the form of a slotted metal sleeve spring and will be retrofitted into the TR-155 transducer for test and evaluation.

8.3 PROGRESS

A research and development contract was awarded to Texas Research Institute, Inc. (N00173-78-C-0156 of 17 July 1978) to accomplish the stated objectives. Most of the initial effort was used for a theoretical stress analysis of the spring configuration and mechanical evaluation of a first test spring. The results were reported in the STRIP FY 78 Fourth Quarter Report.

Work during this quarter was almost exclusively directed toward the fabrication of a dynamic test fixture and dynamic stiffness testing. The primary objectives of this work were (1) to measure the effective dynamic stiffness of the Belleville spring pressure release mechanism presently used in the TR-155 transducer and (2) to verify that the static and dynamic stiffnesses of the sleeve spring are the same. TRI's plans call for measuring the dynamic stiffness of the pressure release by exciting the in phase oscillations of the head and tail masses. In this mode, the resonance frequency is dependent upon the compliances of the head and tail mounts and the masses of the head, tail, and housing. TRI originally proposed (TRI Proposal 8010 of 17 March 1978) instrumenting the dynamic test fixture with accelerometers to obtain displacement and relative phase information for determination of the dynamic stiffness. The work during the past quarter, however, was devoted to attempting to use the piezoelectric stack as a null detector to detect the frequencies of resonance.

A lumped element model of the TR-155 was developed and model element values (mass, stiffness, damping) were taken from available TR-155 data. The model was then used to predict the resonance frequencies associated with the head and tail masses. The resonance frequencies predicted by the model were compared to those measured using the "null detector" technique, but the predicted tail mount resonance was not observed. The net result is that the dynamic stiffness of the pressure release package could not be measured.

Slight modifications in the spring design are expected to eliminate the radial motion at the ends of the spring and preclude any use of interfacing materials.

8.4 PLANS

An inordinate amount of time was spent during the past quarter in attempting to measure the dynamic stiffness of the pressure release. As a result, other task areas suffered and the retrofitting and evaluation tasks are approximately 6 weeks behind schedule. Work during the present quarter will be devoted almost exclusively to those tasks.

9. TASK G-2. TEST AND EVALUATION

9.1 BACKGROUND

The improvements in engineering developments, the development of new test methods, and the new specifications and standards achieved must be utilized to assemble, test, and evaluate prototype transducers so that all implications of proposed changes will be known before introduction to the fleet.

9.2 OBJECTIVES

The general objectives of this task are to evaluate new engineering development transducer projects and to provide quantitative alternatives for solving problems encountered in the operation of fleet sonar systems. Specific objectives for FY-79 are as follows:

a. Determine the feasibility of replacing silicone fluid in operational transducers on a class-by-class basis,

b. Determine the correlation between measurements of noise made in small tanks and those made in a free-field,

c. Evaluate the sleeve spring pressure release mechanism for extraneous noise and pressure independence of acoustic performance.

9.3 PROGRESS

9.3.1 Seven TR-297 type transducers were used in the silicone oil replacement feasibility study. The transducers were subjected to a series of environmental and acoustical tests and no appreciable differences were found to exist between units filled with silicone and castor oils. A recommendation has been made that all three Transducer Repair Facilities replace silicone fluid with castor oil in AT-200 and TR-297 transducers.

Two AT-200 transducers were also evaluated for the effects of the replacement of the rubber window with a thin metal (copper/nickel) window. In order to make a direct comparison, identical acoustic tests were performed with each type of window. The use of the metal window does produce some degradation in acoustic performance, but the transducers still remained within the compendium specifications as amended by NSEA. It should be noted that the specifications listed in the compendium fall short of ensuring the capability of the transducers to meet minimum operational requirements.

The question of whether these transducers could withstand the extremes of storage temperatures when filled with castor oil, fitted with the copper-nickel window, and without the pressure compensator was resolved. They can survive and operate afterward as well as before.

9.3.2 To determine the correlation between the measurements of noise made in small tanks and those made in a free-field, a TR-155 transducer will be used as a test fixture with a small mechanical impulse source attached in the area of the pressure release system. The transducer may then be excited by the same mechanical force under varying acoustic loads, while the response is measured at the transducer's electrical leads. Using this technique, the correlation will be made between the tank and free-field measurements with the net result essentially being a "calibration" of the various measurement systems.

Progress in this area is approximately one quarter behind schedule primarily due to late delivery of instrumentation.

9.4 PLANS

a. A final report will be published during the next quarter which will compare the performance of the TR-297 with the present specifications and make recommendations for new specifications. The report will also provide the opportunity to compare measurements made by the TRF's with those made by USRD on the same units.

b. Completion of the experimental set-up for measurements with the TR-155 test fixture is planned for the second quarter.

c. The first TR-155 retrofitted with the sleeve spring will be tested at NUSC during the second quarter.

10. TASK G-3 ENGINEERING DOCUMENTATION

10.1 BACKGROUND

It has recently become apparent to all facilities working with sonar transducers, that many problems are occurring which possibly could have been avoided. Problems with sonar transducer repair, production and/or testing have been repeated year after year simply because facilities did not see that research and development were needed. The lack of research and development can also be attributed to the fact that facilities have had very little interaction and possible solutions to problems encountered were not well documented. With the increasing numbers of sonar transducer types and acquisitions it will be necessary to know the existing and future needs for research and development. A task has been set aside for researching the severity of sonar transducer problems and establishing possible research and development projects.

10.2 OBJECTIVES

The objectives of this task are:

a. To establish the existing and future needs for sonar transducer research and development.

b. To produce a timetable for research and development programs that relates to sonar transducer acquisitions.

10.3 PROGRESS

This a newly assigned task for FY 79. The first phase of obtaining a listing of all sonar transducer acquistions up to FY 85 is now being completed. It will now be necessary to separate this information into the acquisitions for each fiscal year. The next step will be to contact all Naval facilities.

10.4 PLANS

In order to accomplish this task specific work levels will have to be completed:

a. It will be necessary to determine what sonar transducers on both submarines and surface vessels are to be purchased through and including FY 85. These transducers shall then be listed.

b. Personnel and all facilities that are involved both directly and indirectly in some form of work with sonar transducers will be contacted and visited in order to determine what problems exist. Examples are:

1. Shipyards

    (a) Engineers
    (b) Supervisors

2. Transducer Repair Facilities

    (a) Technicians

        (1) Repair
        (2) Testing

    (b) Supervisors
    (c) Engineers

3. Manufacturers

    (a) Engineers
    (b) Assemblymen
    (c) Technicians

4. Research Laboratories

5. Acquisitions and Program Management Personnel

6. Other Sonar Transducer Support Facilities

7. Training and "In-Fleet" Facilities

    (a) System Operators
    (b) System Repairmen

When corresponding with or visiting these facilities, questions shall be directed in such a manner as to clarify problems that otherwise would be ignored or overlooked. Once the initial discussion is completed, a workable evaluation of the problems that are significant to each facility and sonar transducer can be developed. A few general topics to discuss are listed below:

1. Are the transducers:

    (a) reliable and consistent,
    (b) accurate,
    (c) durable in installation and use,
    (d) easily installed and/or removed,

(e) easy to disassemble and/or reassemble, and

(f) reasonably easy to produce?

2. Are instructions and/or test data:

(a) clear,

(b) used by everyone concerned,

(c) practical,

(d) kept on file, and

(e) easily accessible?

3. Are transducer failures:

(a) being reported and passed on to other participating facilities,

(b) being thoroughly and properly investigated, and

(c) filed for future reference?

4. Is test data acceptable and uniform for such things as:

(a) frequency response,

(b) sensitivity,

(c) power output,

(d) range,

(e) directivity, and

(f) resolution?

With these questions answered, it will be possible to seek pertinent information that, in the past, has not been obvious.

Notes are to be kept for correspondence and each facility visited. These notes will also include suggested solutions received. All information will be complied, reviewed and then placed in a file established for this purpose.

c. There can exist many problems for one transducer or one problem for various transducers. By cross referencing and interfacing it will be possible to determine the severity of the problem or whether a problem even exists. It will also be necessary to footnote all suggested solutions with each problem topic. This information will also include a history of the problem and name(s) of the person(s) contacted.

d. Topics that would be beneficial to sonar transducer support can be presented for research and development. Once projects are assigned, a timetable relative to acquisitions can be established similar to that illustrated in Figure 10.1.

SONAR TRANSDUCER RELIABILITY TIMETABLE
(Months)

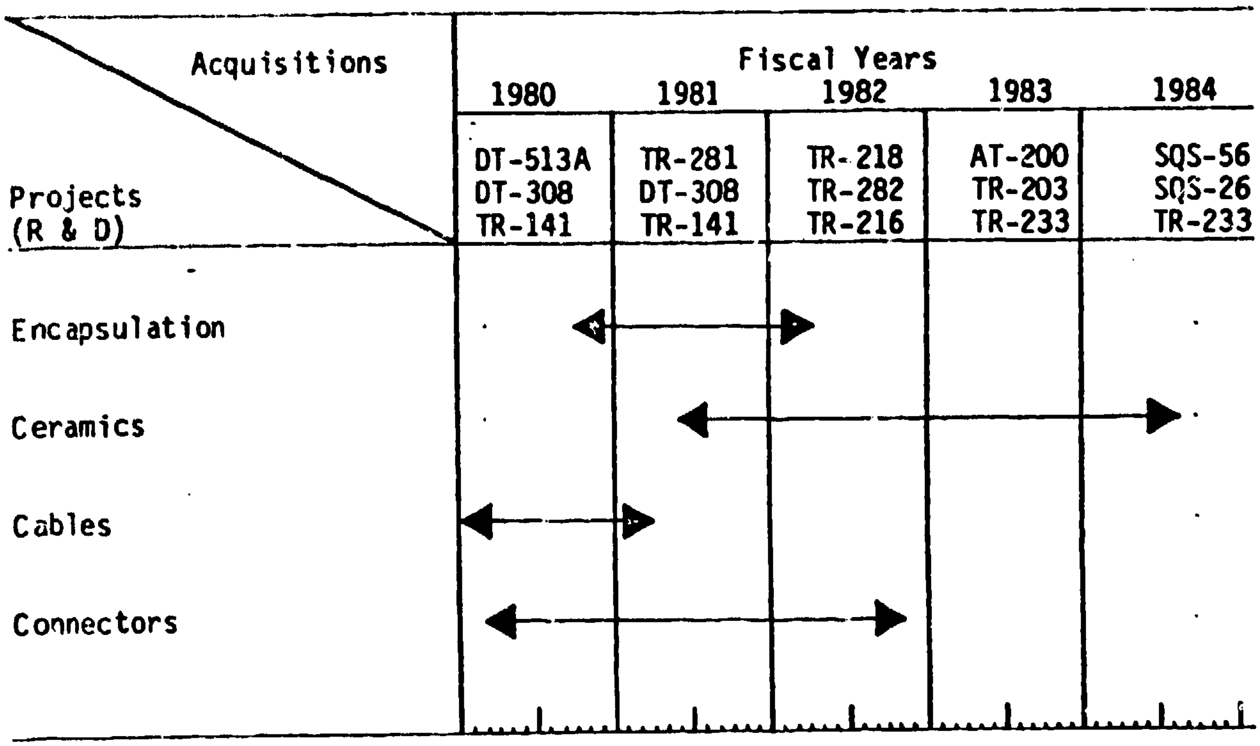

Figure 10.1

(for illustration only)